

What is claimed is:

[Claim 1] 1. A method of operating a hybrid electric vehicle, the hybrid electric vehicle including a power transfer unit adapted to drive a vehicle wheel and having a plurality of gear ratios and at least one power source adapted to drive the power transfer unit, the method comprising:

calculating a speed ratio value based on a drivetrain output speed and a wheel speed;

comparing the speed ratio value to a threshold value; and

inferring a torque disturbance if the speed ratio value is greater than the threshold value.

[Claim 2] 2. The method of claim 1 wherein the hybrid electric vehicle further comprises a drivetrain adapted to transmit power from the at least one power source to a vehicle wheel and wherein the speed ratio value is indicative of the release of potential energy stored in drivetrain component.

[Claim 3] 3. The method of claim 1 wherein the hybrid electric vehicle further comprises a differential coupled to the power transfer unit and a shaft coupled to the vehicle wheel, wherein the speed ratio value is indicative of the release of potential energy stored in the shaft.

[Claim 4] 4. The method of claim 1 further comprising executing a gear backlash mitigation strategy if the speed ratio value exceeds the threshold value.

[Claim 5] 5. The method of claim 4 wherein the hybrid electric vehicle further comprises a starter-alternator adapted to receive power from the at least one power source to apply torque to the power transfer unit and the gear backlash mitigation strategy comprises applying additional torque with the starter-alternator for a predetermined period of time to reduce the duration of a zero-torque condition between gears of the power transfer unit.

[Claim 6] 6. The method of claim 4 wherein the hybrid electric vehicle further comprises a starter-alternator adapted to receive power from the at least one power source and apply torque to the power transfer unit and a differential driven by the power transfer unit, and the gear backlash mitigation strategy comprises applying additional torque with the starter-alternator for a predetermined period of time to reduce the duration of a zero-torque condition between gears of the differential.

[Claim 7] 7. The method of claim 1 wherein the speed ratio value is determined as a function of the expression

$$[DS(t) - DS(t-k)]^A + B / [WS(t) - WS(t-k)]^A + B]$$

where:

A is an even integer,

B and k are constants,

DS(t) is a drivetrain output speed at time t,

DS(t-k) is the drivetrain output speed at time t-k,

WS(t) is an average wheel speed at time t, and

WS(t-k) is the average wheel speed at time t-k.

[Claim 8] 8. The method of claim 7 wherein the drivetrain output speed is measured at an output shaft of the power transfer unit.

[Claim 9] 9. The method of claim 7 wherein the drivetrain output speed is measured at an output shaft of a starter-alternator.

[Claim 10] 10. The method of claim 7 wherein the drivetrain output speed is measured at an output shaft of the power source.

[Claim 11] 11. A method for inhibiting gear backlash in a drivetrain of a hybrid electric vehicle, the hybrid electric vehicle including a power transfer unit having a plurality of gear ratios adapted to drive a set of vehicle wheels, a set of power sources, a starter-alternator adapted to be powered by at least one member of the set of power sources, a first signal indicative of a drivetrain output speed, and a second signal indicative of an average speed of the set of wheels, the method comprising:

calculating a speed ratio value as a function of the first and second signals, the first and second signals being sampled at a first time interval and a second time interval;

determining whether the speed ratio value is greater than a threshold value; and

executing a gear backlash mitigation strategy if the speed ratio value exceeds the threshold value.

[Claim 12] 12. The method of claim 11 wherein the gear backlash mitigation strategy includes reducing an output torque of the starter-alternator for a predetermined period of time.

[Claim 13] 13. The method of claim 11 wherein the gear backlash mitigation strategy includes decreasing power provided by the at least one member of the set of power sources.

[Claim 14] 14. The method of claim 11 wherein the gear backlash mitigation strategy includes reversing a direction of torque provided by the power transfer unit for a predetermined period of time.

[Claim 15] 15. The method of claim 11 wherein the gear backlash mitigation strategy includes reversing a direction of torque provided to the power transfer unit for a predetermined period of time.

[Claim 16] 16. The method of claim 11 wherein the first signal is measured at the power transfer unit.

[Claim 17] 17. The method of claim 11 wherein the first signal is based on a rotational speed of the starter-alternator.

[Claim 18] 18. The method of claim 11 wherein the set of power sources includes an engine, and wherein the first signal is measured at an engine output shaft.

[Claim 19] 19. A method for detecting a zero-torque condition in a drivetrain of a hybrid electric vehicle, the hybrid electric vehicle including a power transfer unit adapted to drive at least one vehicle wheel and having a plurality of gear ratios, a set of power sources including an engine and at least one voltage source, a starter-alternator adapted to be powered by at least one member of the set of power sources, a first signal indicative of a drivetrain output speed, and a second signal indicative of an average wheel speed, the method comprising:

calculating a speed ratio value indicative of a zero-torque condition as a function of the first and second signals, the first and second signals being sampled at first and second time intervals;

determining whether the speed ratio value is greater than a threshold value; and

executing a mitigation strategy to reduce the duration of the zero-torque condition if the speed ratio value exceeds the threshold value.

[Claim 20] 20. The method of claim 19, the hybrid electric vehicle further comprising a differential coupled to the power transfer unit and a shaft coupled to the vehicle wheel, wherein the speed ratio value is indicative of the release of potential energy stored in the shaft.